Final Evaluation Report

Your Details	
Full Name	Atindéhou Massogblé Marc Lucrèce
Project Title	Ecological Importance of large old native trees in the sustainable management of sacred protected areas: Implications for the Conservation of Floristic and Faunal Biodiversity in Benin (West Africa)
Application ID	44309-1
Date of this Report	22 September 2025

1. Indicate the level of achievement of the project's original objectives and include any relevant comments on factors affecting this.

Objective	Not achieved	Partially achieved	Fully achieved	Comments
Document of the diversity and priority LOT species for conservation in sacred protected areas of Benin			✓	We collected data from 500 informants, identified in twenty (20) villages spread around the Sacred Forests of the three cultural landscapes of Ouidah, Dassa, and Nikki. Twenty (20) species, as cultural priority species were reported, such as *Milicia excelsa*, *Ceiba pentendra*, *Khaya senegalensis*, *Vitellaria paradoxa*, *Afzelia africana*, *Antiaris toxicaria*, *Gmelina arborea*, *Irvingia gabonensis*, *Blighia sapida*, *Ficus umbellata*, *Chrysophyllum albidum*, *Pterocarpus erinaceus*, *Zanthoxyllum zanthoxyloides*, *Tamarindus indica*, *Rhodoghaphalon brevicuspe*, *Cola millennii*, *Cola gigantea*, *Sterculia setigera*, *Adansonia digitata*, *and Mansonia altissima* are in decline in the sacred forests of the furrowed areas. The main reasons for the decline of these species are diverse, including: logging due to the characteristics of their stems (accessibility, durability, resistance, and commercial value), erosion of traditional beliefs, urbanization, poor regeneration, intensive agriculture, etc.

Assess of the ecological role of LOT as shelter of faunal and flora biodiversity through sacred protected areas.			✓	We surveyed 15 sacred sites, compiling an exhaustive inventory of old native trees (174 individuals old trees belonging to 25 species) has been carried out in the sacred forests of Fita (Dassa-zoumè), Kpassè (Ouidah) and Serowendiro (Nikki). A targeted sampling approach has been adopted for data collection. In each sacred site, through various line transects of 2km the following data on each old native tree were recorded: species name, geographical coordinates, diameter at 1.30 m above ground level, total height, crown diameter, sacralization indices, diversity of epiphytes/plant parasites, avian colonization, number of habitat cavities of small mammals/batrachians, diversity of tree sprouts under the crown, tree protection, signs of vandalism, access path. The photos below illustrate the data collected and the anthropogenic pressures recorded on threatened species in the sacred forests.
Identify futures prospects for tropical dendroecology through an application of primary steps to the identification of rings of tropical native species for future climate reconstruction of			✓	This part of the study was conducted in one agricultural landscape in southern Benin, near the Kpassè Sacred Forest, located between latitudes 6° 21′ 53″ N and longitudes 2° 05′ 45″ E. A total of 6 young individuals and 6 old trees of the species of *A. africana* & *A. toxicaria* was considered for this part of the research. On each

cultural landscapes				tree, the geographical coordinates were reported and the following dendrometric parameters were measured. These are : - The total height (H) in meters (m) ; - The diameter (D) at 1.30 m ; - The diameter of the crown (Hp) in m. The samples of young individual trees ranging from 53 to 67,3cm were collected from trees that have no sign of obvious rot and damage in the stem. Since we were confronted with the unsuitability of the incremental drill, we took samples of living trees after obtaining permission from the administrative authorities in one agricultural landscape. The study reveals that *Afzelia africana* has thin, clear, sharp rings. These rings are limited by narrow bands of parenchyma associated with vessels, woody rays, and fibrous tissue. These large or small vessels may be solitary, in pairs, or in radial rows. *Antiaris toxicaria*, on the other hand, forms very distinct ring boundaries characterized by a marginal band of parenchyma, which surrounds the entire stem disc. These rings are visible to the naked eye and are quite limited.
Launch of restoration actions, followed by awareness campaigns			✓	For this activity, 200 people were involved (including the local communities, the agents in charge of forest resources, and family collectivity chiefs), and a communication session, awareness, and lobbying session

				were organized. This activity helped with the decision on the strategies and policies of conservation of endangered or vulnerable native and LOT species in Benin. At the end of each session, native plants (those of *Afzelia africana*, *Antiaris toxicaria*, *Rhodognaphalon brevicuspe*, and *Milicia excelsa*) were transplanted with the help of local communities and authorities in the sacred forests. A total of 450 seedlings were established on a combined area of 7,500 m², covering all communes. Among the 450 seedlings planted between May and June 2025, 95% (i.e. 430 seedlings) show an excellent survival rate. Post-germination monitoring is carried out by the coordination teams of the local NGO, partner of this activity, who are present in the various localities. The participation of women—presidents and members of agroforestry associations and cooperatives—was decisive in the success of the awareness campaigns. Posters were also produced (see one sample in Photo 13). Their purpose is to highlight species characterized by large, old fruit trees, which are used by local populations for food, medicine and handicrafts.

2. Describe the three most important outcomes of your project.

a) We were unable to capitalize on the diversity of LOT, which has been formerly used in the implementation of cultural landscape and has been preserved over decades in Benin. By the use of scores ranging from 0 (minimum or least important) to 4 (maximum or most important), we were able to assign to the uses of LOT according to some criteria. Among the twenty (20) species that we reported as cultural priority species, the Top 8 priority species were: *Milicia excelsa*, *Ceiba pentendra*, Vitellaria *paradoxa*, *Afzelia africana*, *Antiaris toxicaria, Rhodognphalon brevicuspe, Adansonia digitata, and Cola gifantea.*

b). For ecological role, we counted a total of 26 species (animal and plant) divided into 22 families and 23 genera as biodiversity associated with species with large old trees. The most represented families in terms of number of species counted are Hirundinidae (3 species) and columbidae (2 species).

c) Before launch of restoration actions, collected seeds were pre-treated and placed in pots arranged in a randomized complete blocks design. We watered the pots frequently to collect germination data (number of seeds germinated every day) and growth parameters (number of leaves, total height, and collar diameter) from the seedlings (collected every five days). In total, 450 seedlings (150 seedlings per site) were produced.

d) These findings advance and confirm that tree-ring analysis should actually be applied to more individual tree species from different areas to obtain accurate, site-specific growth data. We have observed that *A. toxicaria* presents very low autocorrelation, almost non-existent or slightly negative, while *A. africana* presents Moderate, positive autocorrelation, which suggests that successive values in the series are partially correlated. Also, weak correlations between time series of different trees of the same species were observed. This suggests that trees of the same species do not react very consistently to a common signal.

3. Explain any unforeseen difficulties that arose during the project and how these were tackled.

The number of total samples used has been problematic and has impeded building tree-ring chronologies. Indeed, in view of the sacred nature of the trees, permission could not be obtained for the sacred old trees. However, after negotiation with the local authorities of one cultural landscape located in the Guinean zone, permission was obtained for some young individuals of two priority species for conservation, notably *Afzelia africana* and *Antiaris toxicaria*.

4. Describe the involvement of local communities and how they have benefitted from the project.

We actively involved the local community in the project's implementation. Our guides for surveys, interviews, and forest inventory in sacred forests were selected from the local population and paid in accordance with the project's terms and conditions. Restoration activities carried out in close collaboration with the NGO SOS Biodiversity mobilized local authorities, traditional leaders, Water, Forestry, and Hunting officials, teachers, schoolchildren, and students. Their participation

significantly improved the success rate of site restoration. We conducted awareness-raising campaigns among local communities (men, women, youth, farmers, and local authorities).

5. Are there any plans to continue this work?
Msc Angelo Ahissou, under my supervision, will continue the fieldwork (collection and germination of seeds from other priority for the species. For another four to six months. We will remain in contact with the local communities and authorities involved in the restoration of the various sacred areas to continue this activity.

6. How do you plan to share the results of your work with others?
I am supervising Mr. Angelo Ahissou, a master's student at the Applied Ecology Laboratory at the Faculty of Agricultural Sciences. The Rufford Foundation will be mentioned in the document, but also during his oral presentation during his thesis defense. Angelo and I will publish the results in the journal Heliyon. The results of the project were presented during National Tree Day in June 2025. The municipality of each commune was represented, together with the Communal Section of Water, Forests and Hunting, as well as local authorities (President, Secretary, representatives of the royal palaces, and land management officials). The seedlings were handed over to them, and they expressed their commitment to protecting them while showing full openness to other ecological initiatives. The Water and Forests officers present welcomed the action, emphasizing its importance for the preservation of natural resources.

Some parts of the results, especially the ecological role of old trees, have been used and included in my recent article submitted and under review at the Journal Springer as a Book's Chapter (CHAPTER 23, entitled *African Native Large and Old Trees: From Myth to Biodiversity Conservation*).

7. Looking ahead, what do you feel are the important next steps?

For the next steps:
• Extend restoration interventions to other sacred community forests identified during our nationwide surveys to achieve behavioral/perception change and effective conservation of native species with large old trees in Benin
• Organize and conduct awareness workshops with local communities living near sacred areas to promote the adoption and integration of native species into their agroforestry practices as a smart solution to climate change
• Promote the optimization of nutritional health among local communities through the adoption of dietary supplements derived from the active ingredients of native species.
• Extend national behavior change campaigns using local radio podcasts.

8. Did you use The Rufford Foundation logo in any materials produced in relation to this project? Did the Foundation receive any publicity during the course of your work?
I acknowledge in my recent publication on SOS Biodiversity Portal through the following links: Source : (20+) 🌿 Évaluation de la diversité et priorisation... - SOS Biodiversity | Facebook; Source : https://www.facebook.com/share/p/1BW7YpNzy9/

I acknowledged the Rufford Foundation using its logo during my oral presentation at the 11th WorldDendro Conference, Livingstone, Zambia, held from 28th July to 01rstAugust 2025,(Africa).

I also acknowledged the Rufford Foundation in my recent article submitted and under review at the Journal Springer as Chapter (CHAPTER 23 titled «African Native Large and Old Trees: From Myth to Biodiversity Conservation)» of the book edited by David Lindenmayer, Blicharska Malgorzata, and Mikusinskiin Grzegorz.

9. Provide a full list of all the members of your team and their roles in the project.
Local people engaged in the rescue activity prefer anonymity.

ATINDEHOU Massogblé Marc Lucrèce: Project leader and PI, designed the study, operated and led ethnobotany surveys and forestry inventories, data entry, data processing, scientific paper and report writing. Dr Atindéhou has been recommended by head of the laboratory of Applied Ecology to supervise a Master's thesis at (Faculté des Sciences Agronomiques. So, Dr Atindéhou is supervising M. Angelo Ahissou from the Faculté des Sciences Agronomiques, Université d'Abomey-calavi (FSA/UAC), for his master's research on the «Spatial distribution of ancestral forestry species in the cultural landscapes of Benin (West Africa)». He conducted ethno-historical surveys and forestry inventories with me in the sacred forests. I also led results communication and awareness sessions for local communities with the NGO SOS Biodiversity team (Sunday Berlioz Kakpo, Etienne Dégboé, Vivien Trakpaou, Julien Kakpo, Ordo Sègbozo).

Msc Chrisologue Houndjemon: Field Assistant, he was involved in the collection of ethnobotanicals and ecological data for two months.

Msc Esquillin Balt Houndofin: He was a volunteer who worked with me (PI) for data transcription for dendrochronology analysis.

(MA) Dr. Rodrigue Idohou: As a senior researcher, he assisted in the successful implementation, programming, and co-supervision of field data collection activities.

10. Any other comments?

No

ANNEX – Financial Report

[Intentionally removed]

Acknowledgment
We are grateful to the Rufford Foundation for giving us the opportunity to carry out these activities through the funding granted. These activities are of great ecological interest for the knowledge of old native trees in degraded sacred forests through various cultural landscapes in Benin. Our thanks also go to the Laboratory of Applied Ecology (LEA) at the University of Abomey-Calavi, our home institution, for providing us with field equipment and assistance. Our thanks also go to the NGO SOS BIODIVERSITY

Annexe 1: Field photos

Photo 1: Semi-structured individual interviews with selected informants and traditional chiefs

https://www.facebook.com/share/16tqMVScaB/
https://www.facebook.com/share/15xc5NZCHh/

Photo 2: Measurements of dbh1.30m and some old native trees of *Khaya senegalensis* and Adansonia digitata found cut during data collection.




Photo 3: Some pictures of species reported on old native trees: a) bee hive observed in the cavity of *Adansonia digitata* at Damandoudoue sacred forest (Dassa), b: *Bubulcus ibis* present around an old tree, c: presence of *Thryonomys swinderianus* droppings at the foot of an old tree, d: *Streptopelia senegalensis* present on a branch of *Ceiba pentandra* old native tree_ Some epiphytic species_ e: *Diaphananthe ceriflora*, f: *Momordica charantia* g: *Jasminum dichotomum*, h: *Trichillia pleeana* (Source: Atindehou pictures, 2025)

Photo 4: (A) Washer preparation with an orbital sander (Festool Rotex RO 150 FEQ) ; (B-C) Washer of *Afzelia africana* and *Antiaris toxicaria* after preparation

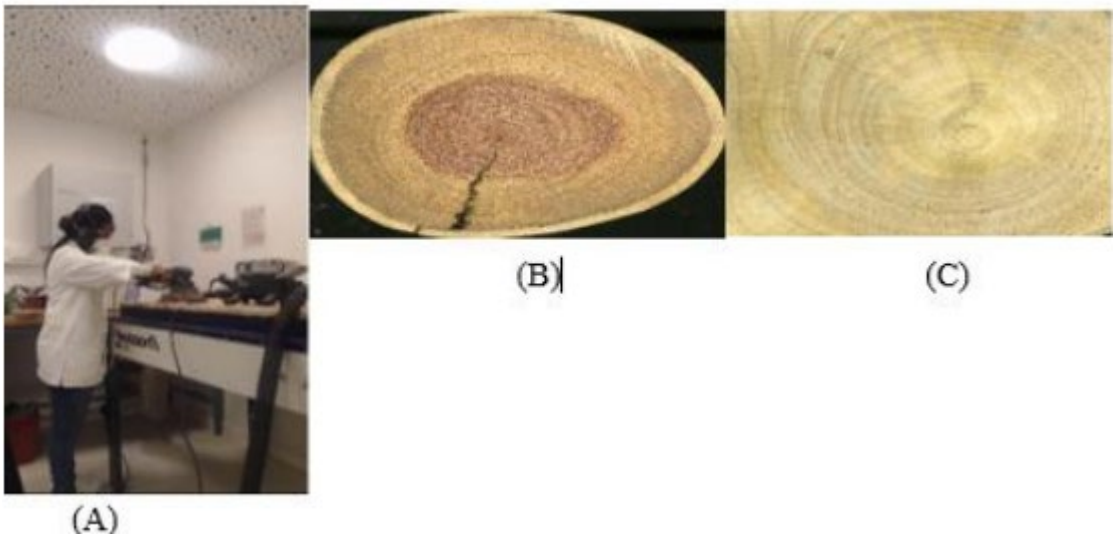


Photo 5: Morpho-anatomical structure of the rings of *A. africana* and *A. toxicaria* (A) Reading of tree-ring by use of Microscope RINNTECH LINTABTM 6, (B-C) the arrows indicate the limits of the rings of *A. africana* and *A. toxicaria* species, respectively

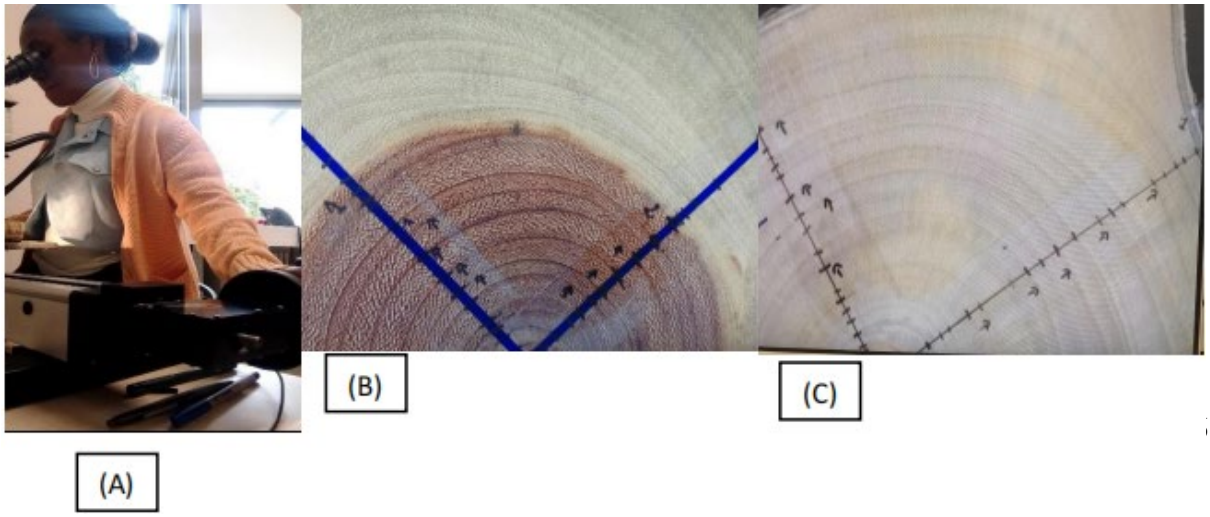
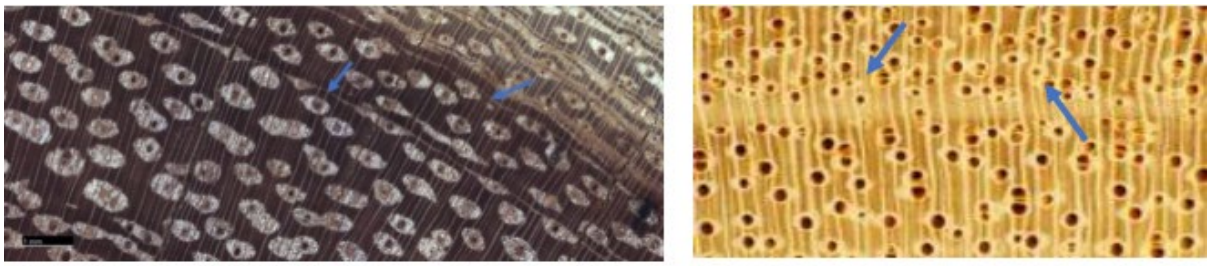


Photo 6: ⟶ Arrows indicate the ring boundary's view through a microscope of A) *Afzelia africana,* B) *Antiaris toxicaria*



(A) (B)

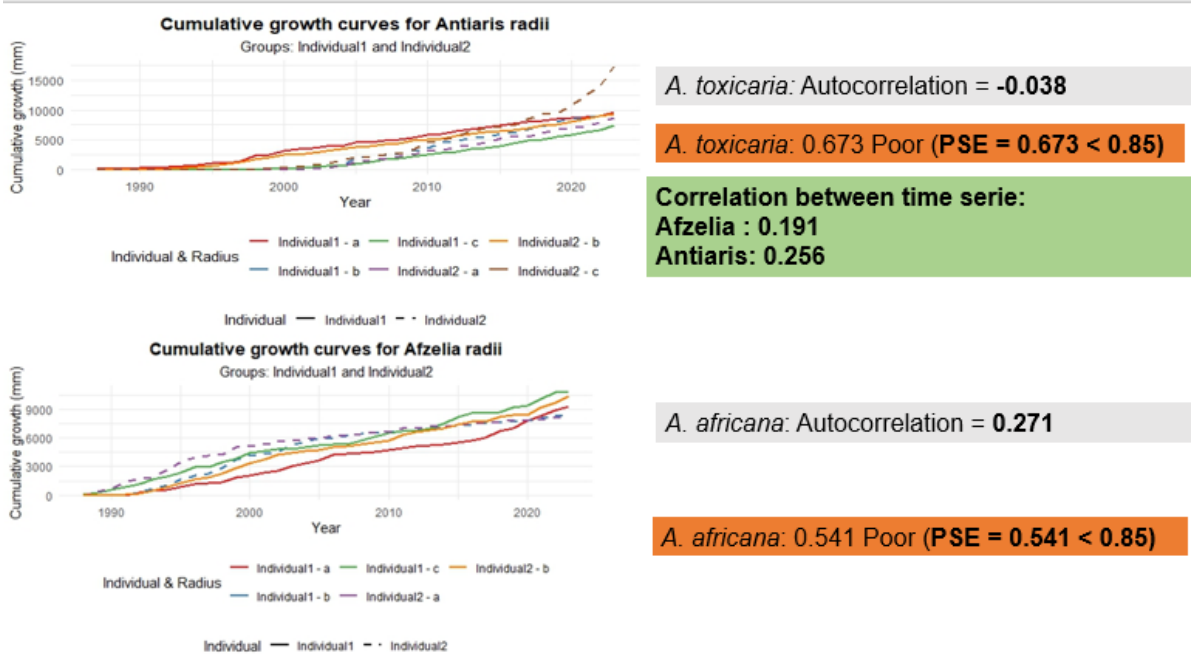
https://www.facebook.com/share/1DXiXrKyqC/

https://www.facebook.com/share/1ACqZ6VTRK/

Photo 8: Plants of *Afzelia africana*, *Antiaris toxicaria*, *Rhodognaphalon brevicuspe,* and *Milicia excelsa* germinated and are ready to be planted in the sacred forest of Totchitché near Savalou.

Annexe 2: Preliminary analysis

Photo 10: Age-radius relationships were estimated using cumulative growth and species Mean_sensitivity First_order_autocorrelation & Inter series correlation



A. toxicaria: Autocorrelation = **-0.038**

A. toxicaria: 0.673 Poor (**PSE = 0.673 < 0.85)**

Correlation between time serie:
Afzelia : 0.191
Antiaris: 0.256

A. africana: Autocorrelation = **0.271**

A. africana: 0.541 Poor (**PSE = 0.541 < 0.85)**

Photo 11: Dependent correlation comparison test between density and the other variables (Dbh, Height, Age) for *Afzelia africana*

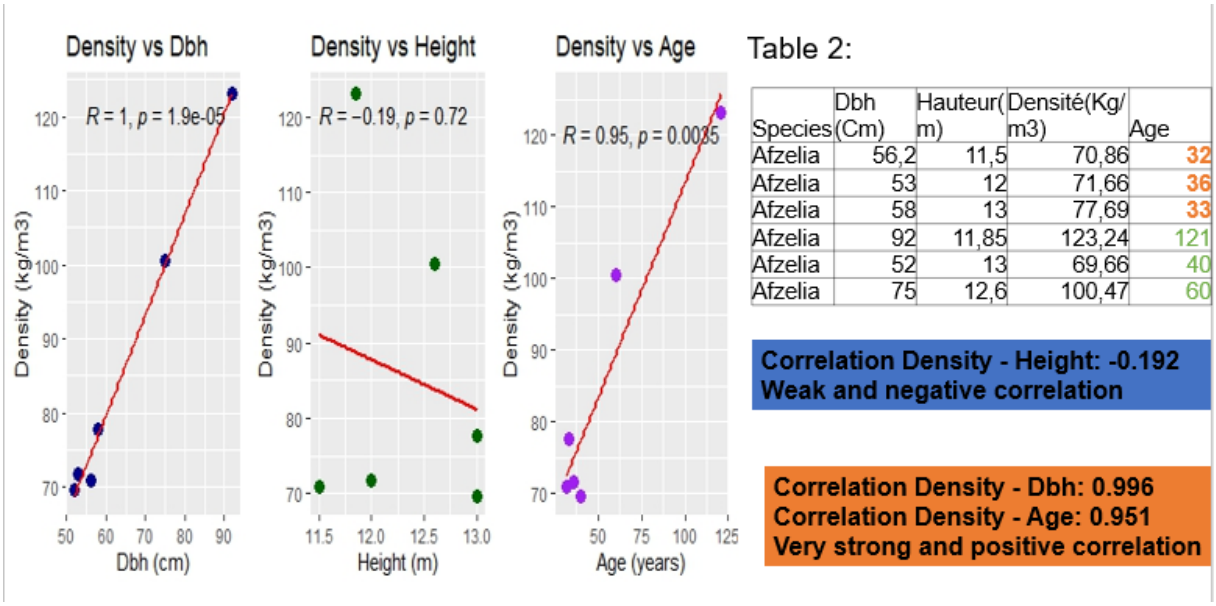


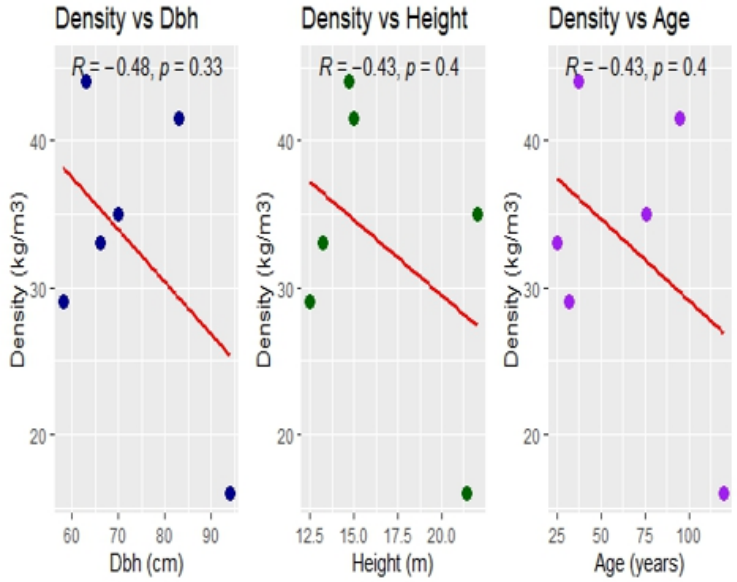
Table 2:

Species	Dbh (Cm)	Hauteur(m)	Densité(Kg/m3)	Age
Afzelia	56,2	11,5	70,86	32
Afzelia	53	12	71,66	36
Afzelia	58	13	77,69	33
Afzelia	92	11,85	123,24	121
Afzelia	52	13	69,66	40
Afzelia	75	12,6	100,47	60

Correlation Density - Height: -0.192
Weak and negative correlation

Correlation Density - Dbh: 0.996
Correlation Density - Age: 0.951
Very strong and positive correlation

Photo 12: Dependent correlation comparison test between density and the other variables (Dbh, Height, Age) for *Antiaris toxicaria*



Correlation Density - Dbh: -0.482
Correlation Density - Height: -0.429
Correlation Density - Age: -0.429
Moderately negative correlation

Table 2

Species	Dbh(Cm)	Hauteur(m)	Densité(Kg/m3)	Age
Antiaris	63	14,7	44	37
Antiaris	66	13,2	33	25
Antiaris	58	12,5	29	32
Antiaris	94	21,45	16	120
Antiaris	83	15	41,5	95
Antiaris	70	22	35	76

Photo 13: Some samples of native trees pictures

Adansonia digitata


Usages et chaine de valeur

Composition

Sels minéraux : pour 100g de pulpe -Calcium430mg -Potassium2220mg
Vitamines : Vitamine C360mg
Les feuilles contiennent du Fe (254mg/100g), de l'acide ascorbique (7mg/100g) et des protéines (4,3mg/100g).
Les graines sont riches en lipides (0,27mg/100g).

Usage alimentaire

- Feuilles utilisées comme légumes
- Graines fermentées pour assaisonner des sauces
- Assaisonnement de bouillies
- Pulpe consommée sous forme de biscuits

Rôle des Vitamines et Sels minéraux

Vitamine C : Absorption du fer et synthèse des globules
Calcium: Structure et la minéralisation du squelette
Potassium: Fonction du système nerveux
Fer: Lutte contre l'anémie et oxygénation des cellules

Cola nitida



Profil nutritionnel et thérapeutique

Fruit: riche en nutriment, en flavonoïde (374,80 µg/100g ± 80,75), en polyphénol (879,87 µg± 5,22/100g).

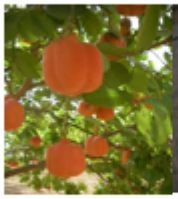
Ecorce et feuille en décoction: utilisée pour traiter les infections digestives et urinaires.

Racine infusée est utilisée pour réduire le taux de glucose dans le sang chez les diabétiques.

Utilité

- **Fruit:** comestible
- **Noix:** culturellement utilisées au Bénin comme constituant de dot pour sceller le mariage et un lien d'amitié entre deux familles et constituent également un repas spirituel d'invocation des divinités lors des rituels traditionnels.

Blighia sapida

Valeur nutritionnelle

Arilles: **Lipides** (51-58%), **Protéines** (2,9 g/100 g) et teneur élevée en **Vitamine C** ;

Feuilles: riches en **Potassium** (K) et **Zinc** (Zn) ;

Huile: composée d'acides gras polyinsaturés, avec une proportion d'oméga-6 pouvant atteindre jusqu'à 50%.

Usage alimentaire

- **Feuilles:** utilisées comme légumes ou fourrage pour les animaux

Usage cosmétique et industriel

- L'extraction de l'huile pour la fabrication des produits cosmétiques

Rôle des Vitamines et Sels minéraux

Potassium : Fonction du système nerveux
Protéines : Favorise la digestion (enzymes digestives).
Lipides : Facilitent l'absorption et le transport des vitamines liposolubles (A, D, E, K).
Vitamine C: Contre les infections bactériennes et permet l'absorption du fer et la synthèse des globules.
Zinc : oligoélément qui lutte contre les problèmes de peau (acné, psoriasis, dermatite...), permet l'activation de la cicatrisation cutanée, la prévention des problèmes prostatiques

Gardenia erubescence



Usage ethnobotanique

Partie utilisée	Utilisation principale
Écorce	Propriétés antioxydantes, traitement des maladies gastro-intestinales
Feuilles	Traitement du paludisme
Racines	Effets aphrodisiaques
Fruits	Préparation de sauces et de soupes
Graine	Cosmétique noire (« Katambiri »)
Bois	Fabrication d'ustensiles (cuillères, couteaux)

Valeurs nutritionnelles

Nutriment	Quantité (pour 100g)
Soufre	0,1521 mg
Potassium	4,058 mg
Calcium	5,6005 mg

Fruit riche en minéraux: **magnésium, zinc, fer, cuivre.**

- Contient des **protéines, lipides et glucides.**
- Valeur énergétique : **376,01 kcal/100g.**

Valeurs économiques

- Vente des fruits sur les marchés ruraux principalement par des femmes.
- Commercialisation des produits dérivés du bois : cuillères, couteaux, manches d'ustensiles.
- Contribution à l'économie locale et génération de revenus pour les ménages.